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Avocado Production in the United States[1]

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INTRODUCTION

Although the avocado has been grown to a limited extent in continental United States for over a half century, the commercial shipping industry was established during the past 25 years.

The important limiting factor in avocado production in the United States is damage from low temperature. The commercial industry is consequently confined to favored sections in southern California and peninsular Florida. In southern Texas and southwestern Arizona, avocado growing is in the experimental stage. The avocado is of importance as a local fruit crop in Hawaii, Panama Canal Zone, Virgin Islands, and Puerto Rico.

Although the avocado is represented by only one species, *Persea americana* Mill., there are three ecological or climatic races—West Indian, Guatemalan, and Mexican. The West Indian race is the common avocado of the tropical American lowlands and, being truly tropical, is seriously injured at temperatures much below 32° F. The Guatemalan and Mexican races are highland types, more truly subtropical, and relatively more resistant to low temperature; the Mexican types are hardier than the Guatemalan.

[1] The sections on avocado insects were contributed by Herbert Spencer, entomologist in charge, Subtropical Fruit Insects Field Laboratory (St. Lucie, Fla.), Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, to whom acknowledgment is hereby made.

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Because of the variation in climatic conditions in the producing centers, avocados are marketed during every month in the year. The main crop in California is produced from November to June, with some fruit during the remainder of the year. In Florida, the main crop was formerly produced from June to October, but this has been changed because of Cuban competition during the summer and early fall season. Practically all new plantings now being made in Florida are of late varieties (fall and winter), and many of the summer-bearing trees have been top worked to late-ripening varieties. The relative importance of the industry in California and Florida is indicated in table 1.

TABLE 1.—*Avocado production, season average price per 1,000 pounds received by farmers, and value for California and Florida, and United States imports, 1929–38* [1]

Year	California			Florida			Both States			Imports, year beginning July
	Production	Price	Farm value	Production	Price	Farm value	Production	Price	Farm value	
	1,000 pounds	*Dollars*	*1,000 dollars*	*1,000 pounds*	*Dollars*	*1,000 dollars*	*1,000 pounds*	*Dollars*	*1,000 dollars*	*1,000 pounds*
1929	800	329	263	840	71	60	1,640	197	323	6,744
1930	4,220	130	549	1,240	96	119	5,460	122.5	668	9,792
1931	5,040	83	418	1,640	72.5	119	6,680	80.5	537	10,194
1932	3,300	85.5	282	2,800	44	123	6,100	66.5	405	8,680
1933	4,900	84	412	4,400	49	216	9,300	67.5	628	5,264
1934	18,600	43.5	809	4,000	37.5	150	22,600	42.5	959	5,622
1935	10,400	86	894	2,000	47.5	95	12,400	80	989	7,530
1936	12,220	65	794	1,200	60	72	13,420	64.5	866	9,118
1937	10,600	76	806	4,200	47.5	200	14,800	68	1,006	11,384
1938	28,200	43	1,213	4,440	32	142	32,640	41.5	1,355	10,316

[1] Data adapted from U. S. Department of Agriculture, Agricultural Statistics, 1940 (*39, table 238*).

On account of the climatic and soil differences in the producing sections, there are differences in varietal and rootstock requirements, in methods of propagation, and in practices of soil management, tree pruning, and pest control. The subject will be considered further mainly on the basis of production sections: Southwestern irrigated section, southeastern humid section, central irrigated section, and Hawaii, Canal Zone, Puerto Rico, and Virgin Islands. However, the unique pollination problem will be first considered.

AVOCADO POLLINATION

The work of various investigators (*7, 9, 19, 22, 23, 24, 31, 32, 33, 43*)[2] has shown that the stamens and pistils of the avocado flower normally mature at different times (dichogamy), that the flowers of a particular tree normally have two distinct periods of flowering instead of one, and that there are two classes of varieties (A and B) from the standpoint of the time of the day when flowers open.

The normal behavior may be summarized briefly as follows: Under favorable weather conditions the flowers of varieties in class A have a first opening during early forenoon when the pistils are receptive but no pollen is shed. By midday they begin to close tightly. At about this time, with some overlapping in certain varieties, the flowers that

[2] Italic numbers in parentheses refer to Literature Cited, p. 26–28.

opened and closed in the forenoon of the previous day have a second or afternoon opening and shed pollen. In class B, the first opening, when the pistil is receptive, normally takes place in the afternoon while pollen is being shed by class A varieties on their second opening. The second opening of class B flowers normally takes place the following morning, when they shed pollen, which is ready for transfer to the receptive pistils of class A flowers opening for the first time. Thus the complete flowering cycle of class A varieties includes the forenoon of one day and the afternoon of the next, extending over approximately 30 to 36 hours, whereas the class B varieties complete their cycle during one afternoon and the next forenoon, in 20 to 24 hours.

The effect of local climatic conditions in modifying the operation of the mechanism described above is recognized as an important factor in facilitating pollination. Climatic conditions are factors in the main avocado-producing districts of California where accumulated grove observations with the principal commercial varieties indicate that adequate pollination occurs without resorting to mixed variety plantings (*9*). With some varieties, as Fuerte, there is sufficient overlap of the two sets of flowers to render them self-fertile; with other varieties, a sufficient percentage of single-cycle flowers (completing their anthesis in one opening) are produced to render self-pollination easy of accomplishment, the only requirement in each case being the activity of bees or other insects (*23*).

In Florida, mixed variety plantings are generally recommended, although a few varieties, notably Trapp, give evidence of being more or less self-fertile, in this case because of single-cycle flowering (*19*, *23*, *31*, *32*, *33*, *43*). The fact that the Collinson variety, whose flowers are completely devoid of pollen, produces normal crops in mixed variety plantings is convincing evidence that cross-pollination is of common occurrence under Florida conditions (*22*).

Davis (*7*) has recently furnished further evidence of the benefit to be derived from cross-pollination under Florida conditions. A grove of Pollock avocados in a solid planting of 490 trees had been given the best of care for 10 years but remained practically barren. After such a complete failure, half of each tree was cut back and grafted to the Lula variety—a variety of class A furnishing pollen in the afternoon when Pollock, of class B, has open, receptive flowers. Ever since the Lula grafts have begun to bloom, this grove has produced an abundant crop of both varieties. A few Pollock trees grafted to Taylor and Fuchsia varieties, also of class A, were likewise effective as pollinizers for the Pollock trees, and the grafted scions have themselves fruited heavily. Thus, a grove that had been maintained at a heavy loss gave a net return of more than $2,600 in the 1938–39 season.

The choice of varieties for planting is therefore influenced by the need, at least in Florida, for the interplanting of reciprocating varieties to facilitate effective pollination. The chosen varieties should also flower at approximately the same time. Keeping bees in or about the orchard is also considered a wise provision during the blooming period. Observations indicate that pollen is carried considerable distance by bees and doubtless by other flying insects.

As a guide to interplanting of varieties of the A and B classes, where necessary, the following classification of selected varieties is

given, the list including both Florida-grown varieties and a few largely confined to the Southwest:

Class A varieties:

Ajax.
Avon.
Booth No. 1.
Collinson.
Dunedin.
Fuchsia.
Gottfried.
Lula.
Peterson.
Pinelli.
Puebla.
Simmonds.
Spinks.
Taft.
Taylor.
Wagner.
Waldin.

Class B varieties:

Booth No. 3.
Booth No. 5.
Booth No. 7.
Booth No. 8.
Dorothea.
Eagle Rock.
Fuerte.
Itzamna.
Linda.
Lyon.
Nabal.
Pollock.
Queen.
Schmidt.
Steffani.
Tonnage.
Trapp.

SOUTHWESTERN IRRIGATED SECTION

Grove Districts

The commercial avocado plantings in the Southwest are almost entirely confined to favorably situated districts in southern California, largely in the coastal and nearby districts from Santa Barbara to San Diego. The principal districts are in parts of San Diego, Los Angeles, and Orange Counties.

In 1939 there were 14,235 acres of avocados in California, with 13,160 acres in bearing and 1,075 acres of nonbearing age (*3*). Of the total planting 8,241 acres, or nearly 58 percent, was in San Diego County, 3,251 acres in Los Angeles County, and 1,997 acres in Orange County. There was a total of 602 acres about equally divided between Ventura and Santa Barbara Counties, 110 acres in Riverside and San Bernardino Counties, and only 34 acres scattered in other locations in the State.

Adaptation

Avocados succeed on a wide range of soils in California from light sandy ones to heavy adobes, but they probably are handled most easily on fairly fertile, medium-textured loams that are fairly deep and well drained. In many sections soil types may vary greatly within small areas, so in choosing a grove site a careful soil study should be made of the location under consideration.

The districts best adapted to avocados are those without extremes of heat or cold, with rather high relative humidities and normally without severe winds. These conditions are similar to those where lemons are most productive, so that successful avocado and lemon plantings are generally found in the same areas.

The West Indian race of avocado varieties are too susceptible to cold injury for culture in California, and hardly a tree of that type is now growing in the State. The Guatemalan varieties are more cold-resistant than the West Indian group, and most of them seem well adapted to coastal or nearby districts in southern California, although different varieties vary considerably in their susceptibility to damage from low temperatures, and no Guatemalan variety is now recommended by the California Avocado Association for commercial planting. Varieties of the Mexican race are most resistant to both heat and cold, although in January 1937 a prolonged period of temperatures below 32° F. with a minimum at least as low as 16° either

killed the tops of many trees or defoliated them to different degrees and injured many fruits. In most districts the Puebla (Mexican) was less seriously injured at that time than the Fuerte (Mexican × Guatemalan hybrid). In many districts the Puebla and Fuerte were about equally frozen, but the Puebla usually returned to normal production more rapidly. The Nabal (Guatemalan) was injured more than the Fuerte but less than the Dickinson (Guatemalan), and the Anaheim (Guatemalan) was in most cases injured more than any other of the important varieties. In most cases the trees were not killed by that freeze, and the characteristic vigorous growth of the avocado resulted in a very rapid recovery during the succeeding season.

Varieties

No variety now grown in California is considered fully satisfactory from the commercial standpoint. The Fuerte fruit is generally regarded as the standard of a desirable commercial variety, but the alternate-year bearing habit of trees of this variety constitutes a serious objection to it from the grower's standpoint. This defect has been largely responsible for the continual trials of new seedlings and other varieties in an attempt to find one that will bear satisfactory fruits with good crops each season.

About two-thirds of the avocado acreage is of the Fuerte variety, which produces about three-fourths of the annual crop. The Nabal, Anaheim, and Puebla are next in rank with from 400 to 500 acres each, followed by Dickinson, Lyon, Spinks, and about 75 other named varieties, some of which were the leading ones in the early days of the industry in this State.

In 1938–39, the season of heaviest production, with 13,160 acres in bearing, the average production per acre was about 2,140 pounds or an average of 25.2 pounds per tree (on the basis of 85 trees per acre). Some orchards 9 to 13 years old averaged 13,000 to 17,000 pounds per acre or 153 to 200 pounds per tree in 1 year, but such yields occur only under favorable conditions.

The varietal problem has received much attention from a committee of the California Avocado Association (*4*), which in 1936 recommended as meriting consideration the following varieties then in commercial production: Fuerte, Puebla, Nabal, Dickinson, and Anaheim. It also stated that the varieties of smaller production, Benedict, Benik, Duke, Murrieta, Queen, and Topa Topa, merited consideration. Continued studies of the adaptability of varieties has resulted in a still further reduction of the number thought suitable for commercial growing, and in the 1940 report of the variety committee of the California Avocado Association (*5*) only the Fuerte was considered as adapted for future commercial plantings though the Anaheim was listed as still in favor in some localities where consistently heavy production was normally obtained. The Duke was also still recommended as satisfactory for the interior valleys. The following newer varieties were listed as still in the experimental stage and in need of wider trial: Hass (a patented variety), Edranol, Ryan, Henry's Select (a patented variety), Hellen, MacArthur, Macpherson, and Nowels.

Brief descriptions of the varieties recommended in 1936 are presented in alphabetical order:

Anaheim (Guatemalan).—Fruit green, oval to elliptical, 18 to 32 ounces; skin thick; quality poor. Oil content, 15 percent. Season, June through August of second year from bloom. Very prolific, regular bearer but very tender to frost.

Benedict (Mexican).—Fruit black, pyriform to obovoid, oblique, 6 to 8 ounces; skin thin; quality good. Oil content, 15 percent. Season, late September and October of year of bloom. Trees frost- and wind-resistant, prolific, best suited to interior districts.

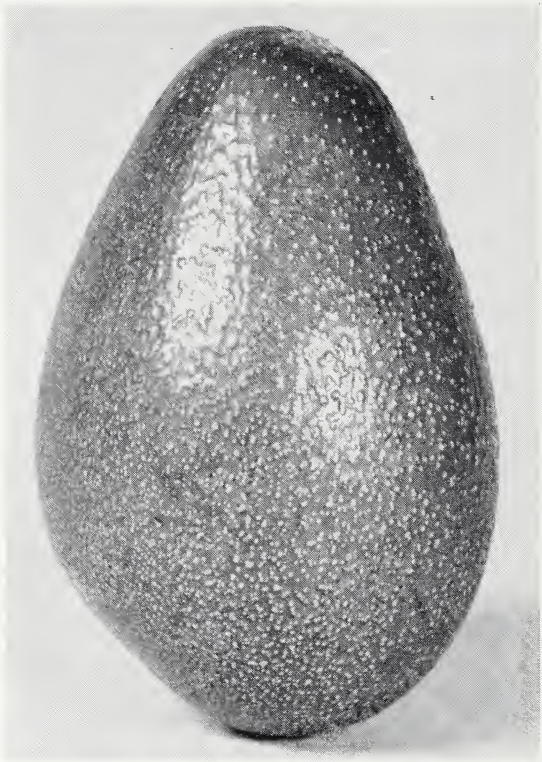

Figure 1.—Typical fruit of the Fuerte avocado. (Approximately seven-eighths natural size.)

Benik (Guatemalan).—Fruit maroon-purple, pyriform to elliptical, 12 to 16 ounces; skin medium-thick; quality high. Oil content, 16 percent. Season, April to August, of second year from bloom. Somewhat weak in type of growth and erratic in production.

Dickinson (Guatemalan).—Fruit dark purple, spherical to obovoid, 9 to 18 ounces; skin thick and very rough. Oil content, 13.5 percent. Season, May to October of second year from bloom. Tree a vigorous and a prolific bearer, but rather tender to frost. Heavy shell makes maturity determination difficult.

Duke (Mexican).—Fruit green, pyriform, 8 to 12 ounces; skin thin; quality excellent. Oil content, 21 percent. Season, September to November of year of bloom. Tree vigorous, very hardy to cold, wind-resistant, productive. Best suited to interior districts.

Fuerte (Guatemalan × Mexican hybrid).—Fruit green, pyriform, 8 to 16 ounces; stem inserted somewhat obliquely; skin thin, pliable and leathery; flavor very good (fig. 1). Oil content, averaging 18 percent with maximum of 25 to 30 percent. Season, November to September in southern California. Tree very vigorous with decidedly spreading type of growth and alternate-year bearing habit. Most frost-resistant of the commercial varieties in California except those of the Mexican race. Best suited to intermediate districts between coast and interior, a shy bearer in Ventura and Santa Barbara Counties. About two-thirds of plantings of the State are of this variety (fig. 2). It is almost ideally adapted to market

Figure 2.—Fuerte avocado tree, 13 years old, in deep clay soil, La Habra district, Calif. (Photographed, July 1940.)

requirements as to size, color, long season of maturity, and hardiness, under California conditions; not adapted to Florida.

Murrieta (Guatemalan) (Murrieta Green).—Fruit green, spherical, 14 to 20 ounces; flavor rich. Oil content, 18 percent. Season, July to September of second year from bloom. A weak grower, must be top worked on older roots, quite susceptible to frost; fruit large for commercial purposes.

Nabal (Guatemalan).—Fruit green, almost spherical, slightly obovoid, 12 to 17 ounces; flavor and quality good. Oil content, 16 percent. Season June to September of second year from bloom. Vigorous in growth and susceptible to tree breakage, rather tender to frost and bearing heavily in alternate years, with fruits too large for easy marketing.

Puebla (Mexican).—Fruit deep maroon-purple, obovoid, frequently somewhat oblique; skin thin, peeling from flesh easily; quality very good. Oil content, averaging 19.5 percent with maximum exceeding

25 percent. Season, November to February. Has long been the second most important variety but is declining in favor because of its tender, thin skin that bruises easily, a decadence of older trees, and maturity period conflicting considerably with Fuerte.

Queen (Guatemalan).—Fruit dull purple, pyriform, 20 to 24 ounces; skin medium thick and woody; quality very good. Oil content, 13.5 percent. Season, July to October of second year from bloom. A fairly reliable bearer but fruits too large except for special markets.

Topa Topa (Mexican).—Fruit black, elongated, oblique pyriform, 6 to 10 ounces; skin thin; quality poor. Oil content, 15.5 percent. Season, September to December of year of bloom. Produces well and sells on appearance; good for local markets.

Propagation

Seedlings of the Mexican race are chiefly used as rootstocks in California, and most successful nurserymen use nothing else. Seeds of the Ganter, Harman, Mexicola, and Topa Topa are in strong demand for rootstocks, and also in different localities a number of large, unnamed Mexican trees are retained by their owners largely because of the steady demand for their seeds.

The seeds are usually planted soon after being removed from the fruits, although they can be held for several months if not allowed to dry out. The general practice is to sprout the seeds, either in coldframes or in the open, before planting in the nursery. Young avocado plants are much less tolerant of transplanting than citrus plants, and precautions should be taken to disturb them as little as possible. Seeds planted in October and November should be ready for nursery planting the following spring, and such seedlings are usually ready for budding some time the following summer or fall, although some nurserymen prefer to delay that operation till the second spring.

For fall budding, matured budwood of the current season's growth is used. It should be obtained only from vigorous-growing, productive trees that are free from any apparent disease. The budded trees will normally be ready for transplanting to the orchard the following spring, 28 to 30 months after the time the seeds were planted.

Nursery trees are normally balled when dry. Planting trees with bared roots is not usually successful and retards the growth of the tree very greatly. The trees are cut back and sometimes partially defoliated a week or more before digging, which is done prior to the starting of spring growth. If kept slightly moist the balled trees can be stored under lath protection for several weeks after digging.

A great deal of top working of established trees has been done in California largely for the purpose of changing seedlings or trees of undesirable varieties to superior ones. Both buds and grafts are used. In top working a considerable variation in congeniality of different seedlings and varieties is well recognized.

Soil Management and Irrigation

The primary purpose of cultivation is the control of weed growth, which would otherwise compete with the trees for minerals and water. Winter or spring disking or plowing is a general practice, and some-

times fertilizers are worked into the soil during this operation. The former practice of cultivation after every irrigation has been largely superseded by the plan of leaving the same furrows for two or more succeeding irrigations until weed growth is sufficient to need control.

Mulched basins are widely used for young trees, particularly on hillside contours and terraces. Under such conditions the need for cultivation is largely confined to keeping the basin and terrace banks free from weeds. Mulching materials usually consist of alfalfa hay, bean straw, or weed growth, which should be kept at least 1 foot from the tree trunk, so that mice nesting in it will be less likely to feed on the trunk bark.

The fertilizer requirements of avocado trees are still largely a matter of conjecture. In some cases applications of nitrogenous fertilizers have caused increased tree growth. General commercial experience indicates that a fertilizer program satisfactory for a citrus grove is also a proper one for avocados. The application of 2 or 3 pounds of nitrogen per tree per year in mature citrus groves is usually beneficial, and similar applications have been found satisfactory in some avocado trials.

Cover crops are being used to some extent in avocado groves, especially in young plantings. In old groves there is usually too much shade from the trees to make the growing of cover crops feasible.

On gentle slopes avocados are usually irrigated by furrows; on steep slopes by a system of contour furrows and basins or by overhead or low-head sprinklers. Use of the low-head sprinkler system is increasing in popularity on all types of plantings because of the uniformity of distribution and efficiency of application of water possible with this system.

The frequency with which irrigation water must be applied will vary widely with soil type and depth, size of trees, and climatic conditions, but at present there is no precise method of determining when water is needed. Probably the most reliable method in use is based upon soil-moisture determinations, but this is relatively expensive. Some growers decide when to irrigate from mere estimation of the moisture in soil samples taken from the top 2 or 3 feet of soil. In some groves water is applied at fixed regular intervals throughout the season. On some soil types, especially heavy or poorly drained ones, it is generally believed that maintenance of soil moisture at percentages near or above the field capacity for long periods favors the development of a trouble commonly called avocado decline, the most obvious symptoms of which are either gradual decrease in growth and amount of foliage or, in some instances, sudden defoliation or drying up of the leaves. Apparently decline follows injury or death of a large part of the root system. On soils where decline is prevalent, it appears probable that even careful avoidance of excessive applications of irrigation water may not prevent the occurrence of decline, as the moisture content of the soil cannot be controlled during rainy periods. It is doubtful whether avocados can be profitably grown on such soils.

The seasonal use of water is largely dependent upon the size of the trees and the climatic conditions. The total seasonal use of water by 10-year-old avocado trees near Fall Brook in San Diego

County was found in 1926 (*2*) to be 15 acre-inches, as compared with 9.5 acre-inches by lemons on the same soil type. For a 13-year-old avocado grove near Vista the total seasonal use of water in 1927 was determined as 15 acre-inches, as compared with only 8 acre-inches for lemons.

Pruning

No experimental results have shown any increase in yield as a direct result of pruning. Some pruning may be necessary to facilitate cultural and harvesting operations, and it is believed to be desirable to keep the tops somewhat open to help control certain insect pests and diseases. Most growers agree that any general pruning reduces the succeeding crop about in proportion to the severity of the cutting and that heavy pruning is justifiable only when necessary to cut back old or diseased trees.

Fruit Storage

Research on avocado storage in California (*20*) has shown that when avocados are stored below 40° F. (the optimum storage temperature for all varieties studied except the Fuerte) fruits of all varieties show internal discoloration and fail to soften when brought to higher temperatures. The Fuerte is subject to internal discoloration at 40° but can be successfully stored at 45°. Under proper storage conditions Dickinson, Queen, Royal, and Taft can be stored for approximately 2 months, the Challenge, Sharpless, and Spinks for 5 to 6 weeks, and the Fuerte, Kist, and Rey for about a month.

Insects

Precautions: Fumigation with the very poisonous hydrocyanic acid gas should be done only by skilled, responsible persons who are thoroughly informed on the subject of fumigation.

As lead arsenate contains two poisons, lead and arsenic, care should be exercised to avoid inhaling the dust. In mixing or handling this material it is advisable to protect the hands in order to avoid possible absorption through cuts or abrasions of the skin; the hands should be kept away from the mouth and should be washed thoroughly before eating. The material should be kept in closed containers, properly labeled, and stored where it is inaccessible to children and domestic animals.

Precautions are also necessary in handling cryolite, in which the poisonous principle is a compound of fluorine.

Care should be taken not to inhale sulfur dust.

Only a very few insects have become of commercial importance, and probably the most serious of these is the latania scale, *Aspidiotus lataniae* Sign. (*16*). This insect is one of the armored scales and

appears as grayish-white circular disks on the leaves, twigs, larger branches, and fruits. Its injury may be sufficient to kill the twigs and branches, and its appearance on the fruits puts them in low or cull grades. Fumigation is the most effective means of control, but on trees too large for fumigation oil spraying will usually give satisfactory control if done thoroughly.

The omnivorous looper, *Sabulodes caberata* Guen., in one of the most destructive leaf-eating insects on avocados in California but is serious only at infrequent periods. When most abundant it is usually attacked by a bacterial disease so that in the succeeding season there is only a light infestation. The amorbia, *Amorbia essigana* Busck. is the other important leaf-feeding insect. Besides eating the leaves much as the looper does, it also scars the young fruits. For the control of both of these pests McKenzie (*16*) recommends spraying with standard lead arsenate 4 pounds, blood albumin 6 ounces, and water 100 gallons. Basic lead arsenate is an alternate treatment and is used as a dust at a strength of 30 percent with 70 percent of sulfur or colloidal clay as a diluent. The sulfur would be of added value if mites are also present.

June beetles sometimes attack avocados, but they have hitherto been controlled by dusting or spraying with cryolite.

The avocado brown mite, *Paratetranychus yothersi* McG., is apparently a rather recent introduction and is active during the summer. Its feeding produces a rusty brown color along the midrib in the central portions of the leaves, and in bad infestations the leaves drop. Sulfur applied with a power duster has given satisfactory control.

Greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), are frequently serious, attacking both foliage and fruit. In bad infestations all green matter in the leaves is extracted, leaving them ashy gray. A spray of 1.5 percent light-medium oil with 1 pint of nicotine sulfate to 100 gallons of diluted spray has been used as a control.

Diseases

Dothiorella rot, caused by *Botryosphaeria ribis chromogena* Shear, Stevens, and Wilcox, is the most troublesome avocado fruit rot in California, but it is usually not very serious except in coastal areas (*12*). It is not generally found until after the fruit is harvested and has begun to soften. Small dark spots appear and spread rather rapidly, but penetrate slowly into the flesh, resulting in a rancid odor and taste. Rain, heavy fog, and overhead irrigation favor its development. The removal of dead twigs, the control of tipburn (nutritional), and the early harvesting of the fruit are preventive measures. A bordeaux and sulfur spray has proved fairly satisfactory.

Probably the most serious disease of the avocado in California is sun blotch, apparently caused by a virus. Small plants may be killed by it. Severely affected old trees may become irregularly bent downward with pendent twigs. Green twigs show an abnormal coloring, varying from indistinct mottling to pale depressed stripes or yellow spots. The fruits may be either normal or marked with depressed, light streaks. The severity of the disease may vary greatly within

a single tree. Vigorous shoots may develop from badly affected branches, and large old trees may appear normal except for a single streaked fruit. The only known method for transmitting it from tree to tree is by budding or grafting. No treatment for the disease is known. Probably the best control measure in selecting budwood is carefully to avoid every tree showing any symptoms of the disease.

Tipburn, for which no causal organism has been found, should probably be considered a symptom of unfavorable growth conditions rather than a disease. It appears as a dying of either the tips or a half or more of the entire leaf in old fully matured leaves. Its correction is probably a matter of determining the unfavorable condition responsible for it.

Although many other insects and fungus diseases have been reported and studied on avocados in California, they are mostly of minor economic importance. Information about them can be secured from special publications (*12*, *16*), from local county agents, or from the Citrus Experiment Station, Riverside, Calif.

Suggested Reference Publications on Avocados in California

California growers of avocados will find many helpful articles, including varietal descriptions and illustrations, in the yearbooks of the California Avocado Association. Various other publications (*6*, *8*, *9*, *12*, *13*, *16*) also contain information that should be of value to them.

SOUTHEASTERN HUMID SECTION

Grove Districts

Commercial avocado production in peninsular Florida is confined primarily to Dade County and the south-central ridge district (Polk and Highlands Counties). On the east coast, north of Dade County, the most important plantings have been made in Palm Beach, Brevard, and Indian River Counties. On the west coast the most important plantings are in Lee, Manatee, and Pinellas Counties. In central Florida, there are occasional small plantings in favorably situated places. The northernmost surviving avocado trees, of the Mexican race, are in northeast Florida, at Earleton, Alachua County, protected on the north by Lake Santa Fe.

In 1936 there were 2,400 acres of avocados in Dade County, with only about one-half of this acreage in bearing. The total acreage in the State does not exceed 3,000 acres.

Adaptation

In addition to the limiting factor of low temperature, the subject of adequate soil drainage and protection from strong winds must be considered in choosing sites for avocado groves in peninsular Florida.

Whereas, in California, under irrigation culture, the varieties of the Mexican race and its hybrids with the Guatemalan are best suited to the climatic conditions, in Florida, the Mexican varieties do not mature their fruit properly. The West Indian, Guatemalan, and hybrids between these and the Mexican furnish suitable varieties.

The West Indian varieties are most tender and will be badly frozen if the temperature falls below 28° F. for some hours. During the 1940 freezes, with temperatures 28° F. or below, West Indian varieties were badly injured or destroyed in central Florida, but Guatemalan, Mexican, and their hybrids have survived except in poorly located plantings without proper air drainage.

The danger from hurricane damage during the summer and early fall must be given consideration. It is desirable to protect plantings with a windbreak. For this purpose, casuarinas are commonly used in Dade County, as well as in the south-central ridge section. Two species, *Casuarina lepidophloia* F. Muell. and *C. equisetifolia* L., commonly called Australian pines, are now extensively planted.

The avocado is intolerant of standing water at the roots, and it is necessary to provide good soil drainage. As a general rule, the water table should not be nearer than 4 to 6 feet to the surface. Drain ditches to carry off surface water in flood periods are essential in soils lacking natural drainage.

Varieties

The varieties of the avocado grown in Florida for the past 25 years have undergone a gradual change in popularity, and the final varieties have apparently not been introduced (*37*, *43*). In Dade County, the important varieties are Fuchsia, Trapp, Waldin, Lula, Wagner, Taylor, and Collinson. Supplementing these varieties may be found occasional trees of Pollock and Simmonds, Linda and Itzamna, and Booth varieties Nos. 1, 3, 5, 7, and 8. On the south-central ridge and in central Florida, Taylor, Lula, and Nabal are the chief varieties, with occasional trees of Collinson, Linda, Gottfried, Waldin, Trapp, and Simmonds. On the east and west coastal regions the varieties have not been standardized, but include trial plantings of most of the above-mentioned varieties with preference in recent plantings for the hardier varieties, as Taylor and Lula.

Brief descriptions of some of the more important varieties follow.

Trapp.—This variety of the West Indian race is notable as the first avocado to be propagated by budding or grafting in this or any other country, so far as known. Previously all avocados had been grown as seedlings, resulting in great diversity of fruit quality, shape, size, and color. George B. Cellon, of Miami, Fla., in 1901 selected and propagated the Trapp avocado, the parent tree of which is still growing at Coconut Grove, Fla. (*37*). The Trapp was the first avocado variety propagated vegetatively in Florida.

The fruit is round-oblate with smooth yellowish-green rind; flesh rich yellow and of excellent flavor (fig. 3, *A*). The weight ranges from 16 to 24 ounces, somewhat too large for present market standards. Its season is September and October. The tree is not a thrifty grower, is tender to cold, and tends to overbear, even at an early age, resulting in a weak or stunted tree. Although formerly a standard for excellence and marketability, it is being replaced by other varieties, later maturing and more thrifty.

Taylor.—This variety, the leading one of the Guatemalan race for Florida planting, originated as a seedling of the Royal, grown at the United States Plant Introduction Garden, formerly located at Miami,

FIGURE 3.—A, Fruit of Trapp avocado; B, fruit of Taylor avocado. (Both approximately natural size.)

Fla. It was planted in 1907, fruited first in 1913, and was introduced in 1914. Although at first regarded as too small a fruit for commercial culture, the recently changed market demand has made the Taylor one of the most popular and profitable of Florida varieties.

The fruit is pear-shaped or rounded oval, small to medium in size, 10 to 18 ounces, with pebbled dark-green rind (fig. 3, *B*). The flesh is light yellow and of good flavor, slightly sweetish. The crop matures from December to about February 15.

The Taylor is a rapid grower, making a slender, upright tree (fig. 4). It fruits regularly and heavily under favorable conditions, and the fruit is fairly resistant to scab and black spot. In hardiness, it has proved outstanding among Florida commercial varieties. Its hardiness, small size, regular bearing habit, and winter season of maturity have all contributed to its commercial importance. A seedling of the Taylor recently introduced as Tonnage is very similar in fruit and tree character to the Taylor, but belongs to class B and hence may be interplanted with Taylor as a pollinizer. It appears to be somewhat less hardy than Taylor, and the fruit matures somewhat earlier.

Fuchsia.—This variety is chiefly notable for its early maturity, late June and July. It originated from a West Indian seedling at Homestead, Fla., and its planting is chiefly confined to that area. The fruit is long oval or pear-shaped, with smooth light-green rind. It is of medium size, 12 to 16 ounces, flesh greenish yellow, of fair to good quality. Although thrifty and prolific, it is not altogether satisfactory as a shipping variety.

Waldin.—This variety also originated as a West Indian seedling at Homestead, Fla., and has been steadily increasing in popularity in that area because of its good bearing habit and season of fruit maturity, October to December. The fruit is rounded oval, asymmetrical, having one side near blossom end decidedly flattened, with smooth greenish-yellow rind. It is of medium size, 14 to 24 ounces, with flesh of pale greenish-yellow color, of good quality. The tree has proved somewhat hardier than other West Indian varieties, and its regular bearing habit further recommends it.

Lula.—This variety is regarded as a Guatemalan×Mexican hybrid, originating as a seedling of the Taft avocado planted by George B. Cellon of Miami, Fla. The fruit is of medium size, 14 to 24 ounces, pear-shaped, more or less necked, with greenish rind flecked with yellow dots; rind smooth or slightly corrugated. The flesh is greenish yellow, of excellent quality. The tree is a rapid, upright grower, comparatively hardy, precocious, and a heavy bearer, its chief defect being its marked susceptibility to scab, necessitating several protecting sprayings. The fruit matures from late November through January and is well suited to present marketing conditions.

Wagner.—Closely resembling the Taylor and of like origin (a seedling of the Royal), the Wagner differs chiefly in its fruit being more rounded and slightly later in maturity, January to March. The tree is not so precocious and prolific as the Taylor and is not being planted to any extent at present.

Collinson.—This variety, a seedling of the Collins, is evidently a Guatemalan×West Indian hybrid and originated at the United States Plant Introduction Garden, formerly located at Miami, Fla. Its

FIGURE 4.—Taylor avocado tree, growing in Dade County, Fla., showing typical upright habit.

handsome appearance and resistance to scab recommended it at once for commercial culture. It was introduced in 1922. The fruit is rounded oval, somewhat asymmetrical, fairly large, 18 to 30 ounces, with smooth, glossy, dark-green rind. The flesh is creamy yellow and of excellent flavor. The crop matures from November into January. The large size of the fruit is at present a marketing handicap. The Collinson is unique in having flowers which are perfect in appearance, but entirely devoid of pollen and hence are entirely dependent on other varieties for pollination (*22*). In mixed plantings, however, it has been a fairly consistent producer, but it is no longer being generally planted.

Nabal.—This variety has already been described on p. 7. Although still on trial in Florida, its merits seem to warrant its inclusion in the list of promising varieties for Florida, where the fruit matures at a favorable time, from late January into March. The tree is a thrifty grower and fairly productive, though inclined to alternate-year bearing.

Itzamna.—This variety, like the Nabal, is of the Guatemalan race and is notable for the late maturing of its crop, March to May. The fruit is slender and pear-shaped, somewhat asymmetrical, with pebbled dark-green rind. It is of medium size, 14 to 20 ounces; flesh yellow, of excellent quality; seed small and tight. Although usually not a heavy producer, the size and late maturity of the fruit recommend it. In some localities difficulty has been experienced in ripening the fruit, even after holding beyond its normal season of maturity.

Other Varieties.—Among other varieties of considerable promise and recently propagated in Florida are the Booth series (Nos. 1, 3, 5, 7, and 8), Ajax, Peterson, Tonnage, Steffani, Nehrling, Avon, Dunedin, Kilgore, and Monroe (a patented variety). Pollock, Simmonds, Eagle Rock, Linda, McDonald, Schmidt, Gottfried, and Winslowson are still to be found in some of the older groves, but shy bearing or defects as to size and color, season of maturity, or shipping quality have gradually eliminated these varieties from recent plantings.

Breeding

Neither in the Southwest nor in the Southeast has yet appeared an avocado variety entirely satisfactory for marketability, yield, and resistance to disease. The breeding technique (artificial hybridization of selected parent varieties) commonly used with many fruits is rendered difficult with the avocado because of the enormous number of flowers produced, only a very small percentage of which are destined to set and mature fruit, even under the most favorable conditions. Recourse may be had to grafting two scions of selected varieties, preferably of A and B classes, on a single stock. The resulting tree may then be tented with muslin at blooming time, placing a hive of bees within the tent to do the work of cross-pollination.

A fair measure of success has been obtained by a modified bagging method. Several large clusters of bloom are covered with ordinary mosquito netting before bloom buds start to open. Then as blooming takes place, every open flower in the first, or receptive, stage is

each day hand-pollinated, using pollen-bearing flowers from the selected male parent. The blooming period usually covers 3 or 4 weeks. In this way, several thousand hand-pollinations may be rapidly made, no emasculation being necessary, because the avocado flower releases no pollen on the first opening. In the 1939 season a total of 130 crossed fruits were set by this method, but only 14 were carried through to maturity.

The planting of large numbers of seed from mixed variety plantings is also being practiced, the resulting seedlings being selected for disease resistance and hardiness before being brought to the fruiting stage (*37*).

Propagation and Rootstocks

The avocado in nursery practice is generally propagated by grafting rather tender tip scions, as either cleft or side grafts on young seedlings, 2 to 4 months old (fig. 5). Seeds are planted in seed

FIGURE 5.—Softwood grafting of avocados, using twig-tip scions: *A*, Cleftgraft inserted but not wrapped; *B*, same, wrapped with Parafilm; *C*, side graft, just inserted and wrapped; *D*, side graft in active growth, stock topped and nearly ready for final cutting back.

boxes during the early fall and grafting can usually be carried out from December to April (*43*). Shield budding, as practiced with citrus trees, is also done to some extent (quite commonly in the Southwest), but the rootstocks should be somewhat larger than for tip grafting. Both methods, or a combination of the two, are used for top working large trees. The tops may be cut to a few feet in height in October or November, and the best of the tender sprouts are cleftgrafted with tender terminal shoots 3 to 4 inches long during

the winter months. If the shoot growth is delayed by cool weather the operation must be carried out at a later date. Shield budding may also be used where this method is preferred.

Cleftgrafting of large limbs and stumps using large scions of year-old wood is also practiced usually in the winter months. This method requires considerable experience and skill and is not recommended for the average amateur propagator.

It has been shown (*34*, *35*, *36*) that fractional embryos can be sprouted or grafted (fig. 6). The grafting of fractional embryos (half seed) is of value for preserving valuable breeding material. Fractional embryo grafts have the advantage that the union is below ground and the scion can sprout again even if the tree is frozen to the ground. However, fractional embryo grafts are more difficult to handle than grafted seedlings.

Seedlings of the West Indian race, largely grown from Cuban seed, are generally used in Florida nursery practice. Where available, Guatemalan and hybrid seedlings have given promising results, but until definite advantage has been shown for such stocks under test conditions, West Indian seedlings, selected for vigor in the seedbed, should be mainly used for commercial planting. Hodgson and Eggers (*10*) have shown that there is a positive correlation between size of seed, seedling, and nursery tree in the avocado, large seeds tending to produce large seedlings, and when budded these result in large nursery trees.

Grove Management

SITES, SOILS, AND AIR DRAINAGE

As the West Indian and Guatemalan varieties are more tender to cold than sweet-orange trees, sites that are seldom visited by severe cold should be chosen. Good air drainage or proximity to large bodies of warm water offers partial insurance against freezing damage, but provision should be made for some method of grove heating if periodic losses of crop or trees are to be avoided. Ward (*41*) has outlined the methods found most effective in protecting avocado groves in the southern ridge section, firing with cordwood of fat pine being found most economical and efficient.

Growers should write to the Federal-State Frost Protection Service, United States Weather Bureau, Lakeland, Fla., for weather forecasts and for information on frost protection.

The avocado can be grown on a wide range of soils, but thrives best in a rich sandy loam. The porous rock-pine soil of the lower east coast where it contains a fair amount of humus and clay (as in the Redland section) is well suited to avocado growing. Hammock soils and the better grade of high pine land are very satisfactory, where other conditions are favorable.

PLANTING AND SPACING

The planting of balled or box-grown plants may be carried out at almost any time of the year, but spring planting in most sections is preferred. By early planting, the first season's growth should be

FIGURE 6.—Grafting of fractional avocado embryos. Type of fractional embryos used in operation: *A*, Dormant; *B*, sprouted fractional embryos. At lower center of *A* and *B*, note wedge-shaped pieces removed from fractional embryos preparatory to insertion of grafts that are sealed in place with melted paraffin. The grafts are placed in a sprouting medium until they have made good growth. *C*, Sprouted fractional embryo graft ready for transplanting. *D*, Graft in *C* after 3 months.

fairly well matured before the advent of cool weather. In setting plants, the root system should be disturbed as little as possible. The planting sites should be well prepared in advance. Partial shading for shade-grown nursery stock is desirable for some time after setting; however, they should be gradually accommodated to full sunlight. Frequent watering is essential in getting the trees well established. Young plants are more susceptible to cold injury than older trees, and mounding with clean sandy soil may be necessary during the first few seasons.

Planting distance varies somewhat with soil type and varieties chosen, but closer spacing than 20 by 20 feet is not advisable. In the lighter soils, 30 by 30 feet is preferable, although for wind protection a closer spacing in one direction, as 30 by 20 feet, is sometimes advisable.

FERTILIZATION

The avocado is a gross feeder, and experience has demonstrated that a bearing tree requires more plant food than a citrus tree of similar size. For young trees, a "grower" formula relatively high in nitrogen, largely of organic sources, is commonly used and applied about six times a year. As trees come into production, the percentage of potash is increased, and applications are made in spring, summer, and fall. No definite amounts may be set as standard, but a bearing tree of 5 to 6 years of age will usually require 30 pounds annually of a standard formula, such as 4–8–6, divided into three applications. At 10 years of age, according to soil and tree condition, it may require double this amount to maintain a regular fruiting condition. Formulas differ according to regional soil conditions, so that until definite experiments are concluded, local practice is the best guide in selecting fertilizers for the avocado grove. Wolfe and Lynch (*42*) have recently reported on the fertilizer requirements of avocados in Florida.

In addition to the commonly used elements, need may be found in some soils for some of the so-called microelements, such as manganese, zinc (*26*), copper, and iron. Hoenshel (*11*) has reported apparent deficiency of one or more of these elements in avocados grown on Everglades muck land. Ruehle and Lynch (*27*) have recently demonstrated copper deficiency in avocado nursery stock and young trees grown on Norfolk sand of the southern ridge section. Bordeaux spray, commonly used in disease control on bearing trees, appears to furnish sufficient copper to meet the needs of the tree under most situations. The county agricultural agent should be consulted for information on avocado fertilizer requirements in each producing section.

CULTIVATION AND MULCHING

Some method of grove management that will conserve moisture, add humus, and thus increase fertility should be planned. In some sections a system of permanent mulching may be used with beneficial results. Excellent mulching material is obtained by growing crotalaria, pigeonpeas, beggarweed, or velvetbeans, cutting them from time to time, and using the hay to mulch the trees. Where this system is used, care must be taken to maintain efficient firebreaks

about the grove. Clean cultivation during the spring dry season followed by the growing of leguminous cover crops to be turned under or disked during the fall or winter is adapted to deep sandy soils, especially while the trees are small and allow space for the growing of abundant cover crops between the tree rows.

IRRIGATION

Any fertilization program will prove ineffective if trees are allowed to suffer for lack of water during drought periods. Experience has demonstrated that an adequate water supply is essential to regular crop production. Ward (*40*) has shown that irrigation in the sand hills of south-central Florida is essential to holding the set of young fruit through the usual spring drought. The type of irrigation system to be used will depend largely on the soil type and contour of the land, though a slip-joint pipe system is most commonly found economical and effective. Krome (*14*) has recently outlined the system found most effective in the oolitic limestone district of southeastern Florida where water is pumped from shallow wells.

PRUNING AND REJUVENATION

No systematic pruning is commonly practiced with avocados in Florida, other than the removal of dead or diseased branches, or the heading back made necessary by freezing or wind damage. However, with certain varieties, as Taylor and Lula, which tend to make very tall slender trees, periodic heading back may be of value to facilitate grove operations, such as spraying and picking. Even with other varieties of normal habit, it has been shown by Traub and Robinson (*38*) that aged trees or trees that have become devitalized from lack of care often may be rejuvenated by severe pruning back, leaving only 3 to 5 feet of the original trunk (fig. 7). Such drastic treatment must be accompanied with adequate feeding and irrigation when necessary to force out an abundance of new vigorous shoots of fruit-bearing character. By the second year the new branches thus produced should be yielding a fair crop of fruit. The cut-back trunks should be protected against sunburn by whitewashing or shading, and the cut surfaces should be painted with some good wound dressing.

The grower should plan by proper feeding to keep his trees in excellent condition indefinitely and thus obviate the necessity for such drastic rejuvenation pruning. Such a program should become more feasible in the future as the food requirements of the avocado under local conditions are determined by further scientific experimentation.

YIELDS

Accurate data on the yield of avocado trees under grove conditions are not available for a variety of reasons. Losses due to storms, floods, and freezes, together with the reworking of old varieties have affected so many of the larger plantings that normal yield records have suffered many lapses (*43*). With alternate-year bearing more or less common, an average of 1 to 2 crates of 40 pounds each per tree per season is a fair expectation for most varieties, although occasional yields of 5

to 10 times this amount may be reported. With the graduai elimination of shy-bearing varieties and the adoption of better grove practices, it is believed that the average production might easily be doubled in the near future.

FIGURE 7.—Rejuvenation of 15-year-old avocado trees: *A*, Unpruned Lula tree; *B*, similar tree in third year after severe cutting back; *C*, type of growth on unpruned trees with twigs dying back; *D*, luxuriant foliage on pruned tree.

FRUIT STORAGE

Lynch and Stahl (*15*) have shown that the principal Florida-grown varieties require different storage temperatures. Pollock and Trapp varieties were successfully stored for 28 days at 42° F., but were injured at 37°; the Lula and Taylor were successfully stored at 37°; the Waldin and Collinson did not react favorably to temperatures of 37°, 42°, or 48°.

Disease and Insect Control

Protective sprays (chiefly bordeaux mixture for scab, blotch, and black spot infection) are generally essential to the production of high-grade fruit. Precautions against both fungus and insect injuries are discussed in detail in special publications (*17*, *18*, *21*, *25*, *30*, *43*).

See precautions in using poisonous substances on page 10.

Suggested Reference Publications on Avocados in Florida

Florida growers of avocados will find papers on many phases of avocado culture in the annual proceedings of the Florida State Horticultural Society. Various other publications (*1*, *17*, *18*, *24*, *28*, *29*, *30*, *32*, *37*, *43*) also contain information that should be of value to them.

CENTRAL IRRIGATED SECTION

Avocados have been grown in the lower Rio Grande Valley for many years, but practically all of the plantings are of the dooryard type. Numerous attempts have been made to establish commercial avocado groves in this section, but the results have, until recently, been very discouraging. Many thousands of dollars have been spent for avocado nursery stock of both California and Florida origin, but the number of thriving avocado trees in the valley is still very small. There are a few so-called commercial plantings, but the production of valley-grown avocados is still a negligible quantity.

Most of the dooryard plantings are seedlings of Mexican origin, but there are a few thriving seedlings of the West Indian type to be found in this section. Many of the better seedlings appear to be of hybrid origin.

Within the past few years, it has been found as a result of experiments at Texas Substation No. 15, Weslaco, that seedlings of certain trees produce very vigorous understocks, and it now appears to be desirable to attempt to propagate the more hardy commercial varieties on these better adapted rootstocks. Recent improvements in methods of propagation will facilitate such attempts.

The recent discovery by the Superintendent of the Texas substation at Weslaco of a number of healthy trees of several varieties has reawakened interest in the possibilities of successful avocado plantings. Near La Feria he found under cultivation trees of Lula, Linda, Gottfried, and Fuerte varieties, the oldest of them more than 12 years old. All of these were grown from Florida nursery stock propagated on West Indian rootstocks. These varieties are all rated as fairly hardy and afford a basis for further trials in favorable locations. All but the Linda (Guatemalan) are of hybrid origin giving evidence of having one parent of the Mexican race. If, as now appears probable, there are strains of the West Indian race that are adapted to local conditions approximately as well as the Mexican race, formerly given preference as rootstocks, the problem of avocado growing in southern Texas will be greatly simplified.

HAWAII, CANAL ZONE, PUERTO RICO, AND VIRGIN ISLANDS

Although not at present produced in quantities for export to continental United States, the avocado is an important article in the diet of residents in Hawaii, Canal Zone, Puerto Rico, and the Virgin Islands. Most of the production in these areas comes from seedling trees, but trials of introduced and selected local varieties are under way. With an improved standardized product, there will doubtless result the gradual establishment of an industry of some importance in the most favorable locations, although shipping difficulties may prevent any large expansion for export trade. In Puerto Rico the prevailing heavy soils are not well suited to avocado growing, but there are areas of sandy, well-drained soils in the southwestern parts of the island where, under irrigation, avocado growing might become a fairly important industry. Likewise, in the Virgin Islands, there are areas well suited to avocado culture.

For further information the reader should write to Hawaii Agricultural Experiment Station, Honolulu, T. H.; Canal Zone Experiment Gardens, Summit, C. Z.; Puerto Rico Agricultural Experiment Station, Rio Piedras, P. R.; or Federal Experiment Station, Mayaguez, P. R.

SUMMARY

Avocado production is definitely established in the United States as a fruit industry of rapidly increasing importance. In the 10 years from 1929 to 1938 the production increased from 1,640,000 pounds to 32,640,000 pounds. The two main producing States, California and Florida, differ so markedly in climate and sols, with resulting differences in variety and rootstock adaptations and cultural practices, that they are herein separately discussed.

The California industry is at present based mainly on a single variety, the Fuerte, though a superior variety from the standpoint of more regular production is recognized as desirable. In commercial practice, the Fuerte has been found self-fertile, requiring no interplanting of other varieties for pollination purposes. Although the main shipping season for the State is from November to June, there is a considerable volume of fruit maturing every month in the year. Seedlings of the Mexican race are generally used as rootstocks.

Irrigation is universally practiced under California conditions, about 15 acre-inches being a normal requirement. Fertilization as commonly practiced there is similar to that given citrus trees.

Measures for the control of insect pests and fungus diseases are discussed, and recommendations are given.

In Florida several varieties are usually included in any grove planting, not only to facilitate pollination but also to extend the shipping season over several months. Summer- and early-fall-maturing varieties are being superseded to a large extent by late-fall- and winter-maturing varieties, such as Lula and Taylor, which are also hardier than the earlier maturing varieties. The main shipping season extends from October to March.

Seedlings of the West Indian race are commonly used as rootstocks in nursery practice in Florida.

Low temperatures, floods, or high winds are the main hazards in avocado growing in Florida, and sites should be chosen with these factors in mind.

The avocado is a gross feeder, and experience in Florida indicates that a bearing avocado tree requires heavier fertilization than a citrus tree of similar age.

Avocado growing in the lower Rio Grande Valley of Texas has not as yet reached commercial proportions. Selection of varieties and rootstocks adapted to local conditions is in progress.

In Hawaii, Canal Zone, Puerto Rico, and Virgin Islands, the avocado is grown chiefly for local use.

LITERATURE CITED

(1) Abbott, Ouida D.
1931. general properties of some tropical and sub-tropical fruits of florida. Fla. Agr. Expt. Sta. Bul. 237, 32 pp., illus.

(2) Beckett, S. H., Blaney, Harry F., and Taylor, Colin A.
1930. irrigation water requirement studies of citrus and avocado trees in san diego county, california, 1926 and 1927. Calif. Agr. Expt. Sta. Bul. 489, 51 pp., illus.

(3) Blair, R. E., and Phillips, H. C.
1940. acreage estimates, california fruit and nut crops as of 1939. U. S. Dept. Agr., Agr. Market. Serv., and Calif. Dept. Agr., 29 pp.

(4) California Avocado Association.
1936. report of the variety committee of the california avocado association, 1936. Calif. Avocado Assoc. Yearbook 1936: 23–30.

(5) ———
1940. report of the variety committee—1940. Calif. Avocado Assoc. Yearbook 1940: 23–30.

(6) Church, C. G., and Chace, E. M.
1922. some changes in the composition of california avocados during growth. U. S. Dept. Agr. Bul. 1073, 22 pp.

(7) Davis, Sam J.
1939. avocado growing in the redland district. Fla. State Hort. Soc. Proc. 52: 71–73.

(8) Haas, A. R. C.
1937. chemical composition of avocado fruits. Jour. Agr. Res. 54: 669–687, illus.

(9) Hodgson, Robert W.
1930. the california avocado industry. Calif. Agr. Col. Ext. Cir. 43, 86 pp., illus. [Revised, 1934.]

(10) ——— and Eggers, E. R.
1938. correlations between size of seed, seedling, and nursery tree in the avocado. Calif. Avocado Assoc. Yearbook 1938: 92–96, illus.

(11) Hoenshel, Paul.
1939. avocado growing in the okeechobee region. Fla. State Hort. Soc. Proc. 52: 69–71.

(12) Horne, W. T.
1934. avocado diseases in california. Calif. Agr. Expt. Sta. Bul. 585, 72 pp., illus.

(13) ——— and Palmer, D. F.
1935. the control of dothiorella rot on avocado fruits. Calif. Agr. Expt. Sta. Bul. 594, 16 pp., illus.

(14) Krome, W. H.
1941. grove irrigation in dade county. Fla. State Hort. Soc. Proc. 53: 163–167.

(15) Lynch, S. J., and Stahl, A. H.
1939. studies in the cold storage of avocados. Fla. State Hort. Soc. Proc. 52: 79–81.

(16) McKenzie, Howard L.
1935. BIOLOGY AND CONTROL OF AVOCADO INSECTS AND MITES. Calif. Agr. Expt. Sta. Bul. 592, 48 pp., illus.
(17) Moznette, G. F.
1922. THE AVOCADO: ITS INSECT ENEMIES AND HOW TO COMBAT THEM. U. S. Dept. Agr. Farmers' Bul. 1261, 32 pp., illus.
(18) ———
1922. THE RED SPIDER ON THE AVOCADO. U. S. Dept. Agr. Bul. 1035, 15 pp., illus.
(19) Nirody, B. S.
1922. INVESTIGATIONS IN AVOCADO BREEDING. Calif Avocado Assoc. Rpt. 1921–22: 65–78, illus.
(20) Overholser, E. L.
1925. COLD STORAGE BEHAVIOR OF AVOCADOS. Calif. Avocado Assoc. Ann. Rpt. 1924–25: 32–40.
(21) Quayle, Henry J.
1938. INSECTS OF CITRUS AND OTHER SUBTROPICAL FRUITS. 583 pp., illus. Ithaca, N. Y.
(22) Robinson, T. Ralph.
1930. POLLEN STERILITY IN THE COLLINSON AVOCADO. Jour. Hered. 21: 35–38, illus.
(23) ———
1931. SOME ABERRANT FORMS OF FLOWER MECHANISM IN THE AVOCADO. Calif. Avocado Assoc. Yearbook 1931: [107]–111, illus.
(24) ——— and Savage, E. M.
1926. POLLINATION OF THE AVOCADO. U. S. Dept. Agr. Dept. Cir. 387, 16 pp., illus.
(25) Ruehle, Geo. D.
1939. EXPERIMENTS FOR THE CONTROL OF FRUIT SPOTS OF THE AVOCADO. Fla. State Hort. Soc. Proc. 52: 73–78.
(26) ———
1940. ZINC DEFICIENCY OF THE AVOCADO. Fla. State Hort. Soc. Proc. 53: 150–152.
(27) ——— and Lynch, S. J.
1940. COPPER SULFATE AS A CORRECTIVE FOR DIEBACK, A NEW DISEASE OF THE AVOCADO. Fla. State Hort. Soc. Proc. 53: 152–154, illus.
(28) Stahl, Arthur L.
1933. CHANGES IN COMPOSITION OF FLORIDA AVOCADOS IN RELATION TO MATURITY. Fla. Agr. Expt. Sta. Bul. 259, 61 pp., illus.
(29) Stennis, Mary A.
1931. FLORIDA FRUITS AND VEGETABLES IN THE FAMILY MENU. Fla. Dept. Agr. Bul. (n. s.) 46, 100 pp., illus.
(30) Stevens, H. E., and Piper, R. B.
1941. AVOCADO DISEASES IN FLORIDA. U. S. Dept. Agr. Cir. 582, 47 pp., illus.
(31) Stout, A. B.
1923. A STUDY IN CROSS-POLLINATION OF AVOCADOS IN SOUTHERN CALIFORNIA. Calif. Avocado Assoc. Rpt. 1922–23: 29–45, illus.
(32) ———
1933. THE POLLINATION OF AVOCADOS. Fla. Agr. Expt. Sta. Bul. 257, 44 pp., illus.
(33) ——— and Savage, E. M.
1925. THE FLOWER BEHAVIOR OF AVOCADOS WITH SPECIAL REFERENCE TO INTERPLANTING. Fla. State Hort. Soc. Proc. 38: 80–91.
(34) Traub, Hamilton P., and Auchter, E. C.
1933. SPROUTING AND GRAFTING FRACTIONAL PARTS OF AVOCADO EMBRYOS WITH ATTACHED COTYLEDONOUS MATERIAL. Science (n. s.) 78: 389–390.
(35) ——— and Auchter, E. C.
1934. PROPAGATION EXPERIMENTS WITH AVOCADO, MANGO, AND PAPAYA. Amer. Soc. Hort. Sci. Proc. (1933) 30: 382–386.
(36) ——— and Auchter, E. C.
1934. AVOCADO FRACTIONAL EMBRYO GRAFTAGE. Fla. State Hort. Soc. Proc. 47: 129–130.
(37) ——— and Robinson, T. Ralph.
1937. IMPROVEMENT OF SUBTROPICAL FRUITS OTHER THAN CITRUS. U. S. Dept. Agr. Yearbook Separate 1589, 77 pp., illus.

(38) TRAUB, HAMILTON P., and ROBINSON, T. RALPH.
1939. EFFECT OF VARIOUS DEGREES OF HEADING BACK ON SUBSEQUENT GROWTH OF AVOCADO TREES. Fla. State Hort. Soc. Proc. 52: 43–48, illus. [Note: Figs. 3 and 4, Pl. 1, are reversed.]
(39) UNITED STATES DEPARTMENT OF AGRICULTURE.
1940. AGRICULTURAL STATISTICS 1940. 737 pp. Washington, D. C.
(40) WARD, W. F.
1939. THE AVOCADO INDUSTRY OF CENTRAL FLORIDA. Fla. State Hort. Soc. Proc. 52: 67–69.
(41) ———
1940. OBSERVATIONS ON PROTECTION OF AVOCADOS FROM COLD INJURY. Fla. State Hort. Soc. Proc. 53: 158–161.
(42) WOLFE, H. S., and LYNCH, S. J.
1940. FERTILIZER STUDIES WITH AVOCADOS. Fla. State Hort. Soc. Proc. 53: 147–150.
(43) ——— TOY, L. R., and STAHL, ARTHUR L.
1934. AVOCADO PRODUCTION IN FLORIDA. Fla. Agr. Expt. Sta. Bul. 272, 96 pp., illus.

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